

Better Scheduling of the IVS-Intensives for Improved UT1 Estimates John Gipson¹, Karen Baver¹, Kerry Kingham², Merri Sue Carter³



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1. Introduction

The primary purpose of the IVS-INT01 Intensive sessions is the estimation of UT1. Improving the accuracy and precision of the UT1 estimates is an important goal in the scheduling of these sessions. In 2009 and 2010 the GSFC VLBI Analysis Center requested and received the use of nine IVS R&D sessions, RD0907 through RD0910 and RD1001 through RD1005, for the evaluation of a new strategy for scheduling the IVS-INT01 sessions. Analysis of the 2009 R&Ds was sufficiently promising that in July 2010, USNO began to use the new strategy to schedule operational IVS-INT01 sessions on alternating days. In this poster we present results from our analysis of the R&D and the alternating operational sessions.

2. Definitions

Session types: We discuss several kinds of 1-hour IVS-INT01 Intensive sessions.

- USNO: operational sessions scheduled by USNO through June 2010. These sessions observe a restricted list of "sources" (quasars) (the original scheduling strategy).
- STND: R&D Intensives that used the same standard sources as in USNO (the original scheduling strategy).
- TEST: R&D Intensives that used an enlarged source list consisting of all sources that are mutually visible at Kokee and Wettzell (the new scheduling strategy).
- ALTOP: operational Intensives scheduled by USNO starting in July 2010 and alternating between the original (ALTOP-O) and new (ALTOP-N) scheduling strategies.

Greenwich Sidereal Time: The IVS-INT01 Intensive sessions only observe a small part of the sky, which changes depending on the Intensive's date and time of day and determines the available sources. To compare the scheduling strategies in the same part of the sky, we need something that is unambiguously associated with the observable part of the sky. The Greenwich Sidereal Time (GST) serves this function. Sessions which start at the same GST will sample the same part of the sky.

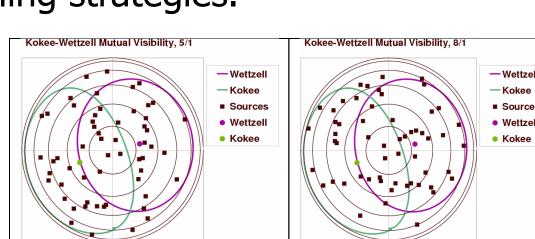


Figure 1. Observable sky at ~GST 09:09:00 (left) and ~GST 15:11:00 (intersection of colored ovals, each of which shows source visibility at a station). The sky has rotated ~90° around the center of the plot.

3. Original and new scheduling strategies

Better sky coverage is empirically linked to improved precision and accuracy of estimates. The original strategy uses only the scheduling Because strong sources are unevenly distributed, at some times of the year there are only a few available, which can result in poor sky coverage. Furthermore, because the number of scheduled sources is small, the original strategy tends to schedule sources many times in one session. The loss of a single source can lead to dramatic changes in sky coverage, which in turn has a large effect on the UT1 formal errors.

	ORIGINAL		NEW	
Typical Sky Coverage	GST 011110		GST 011110	E
Avg. # of observations *	28.3	√	23.2	
Avg. # of sources *	10.6		18.5	✓
Source strength	better	✓	worse	
Sky coverage	narrower		wider	✓

* Based on an initial evaluation of the strategies.

The new strategy schedules more sources, achieving greater sky coverage. The trade off is that it uses weaker sources and achieves fewer observations. Table 1 compares the strategies.

4. R&D Experiment design

We divided the R&D network into two parts—the single baseline Kokee-Wettzell network and a remaining network consisting of ~5 stations. Each network was scheduled independently. The primary purpose of the larger network was to serve as an independent check on UT1.

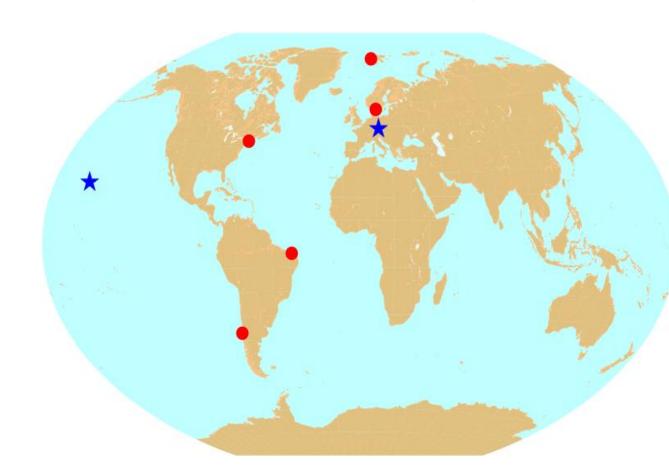
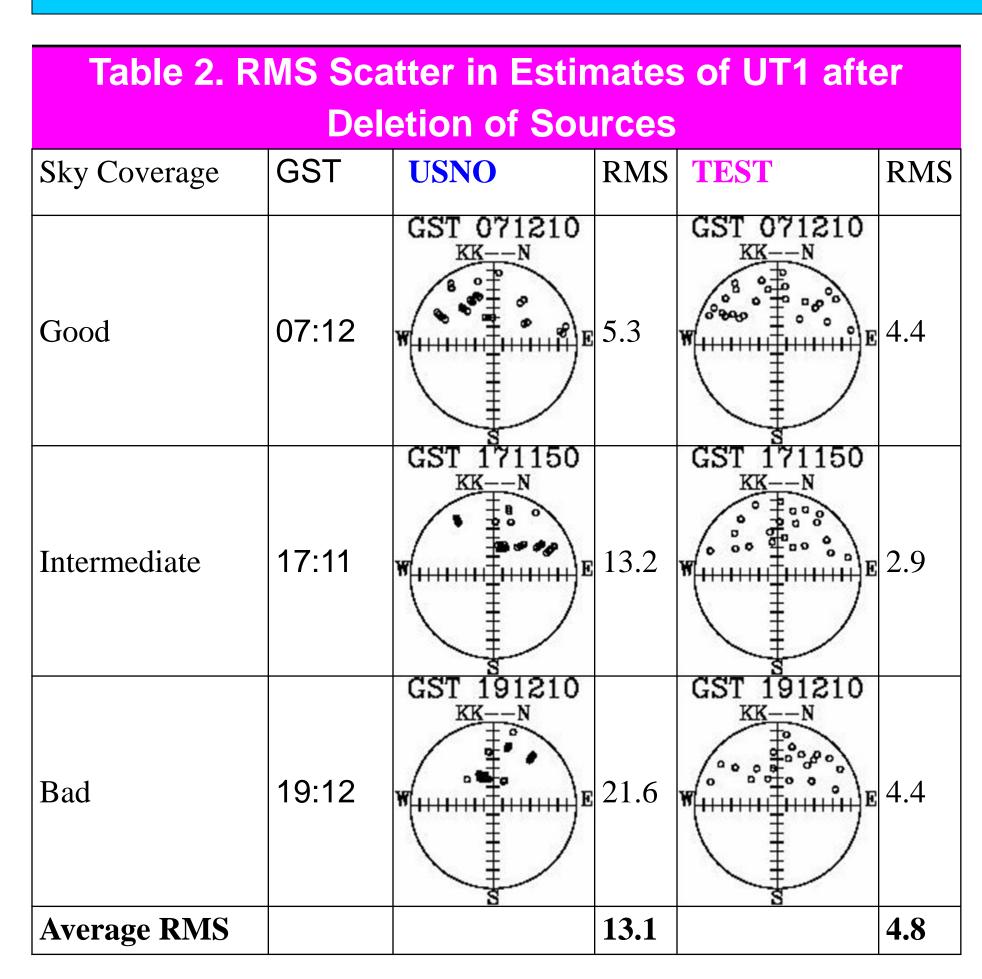


Figure 2. Typical R&D network. Kokee and Wettzell (★) are used in the Int1 Intensive network.

Because Kokee and Wettzell are used in the USNO Intensives, they were not available for the two hour period immediately prior to, during and after the USNO Intensives. Hence we had use of them for 22 hours in each R&D. We used this time to schedule a series of one-hour Intensives, alternating between the STND strategy and the TEST strategy. During the first R&D, we scheduled the first Intensive session, a TEST, at GST 15:07, then a STND at GST 16:07, and so on. We adjusted the start time of the Intensive series in the next four R&Ds so that we sampled the same part of the sky (using the TEST strategy for odd numbered GSTs and STND for even GSTs). In the final four Intensives, we exchanged the strategies.

5. Robustness of TEST R&D sessions



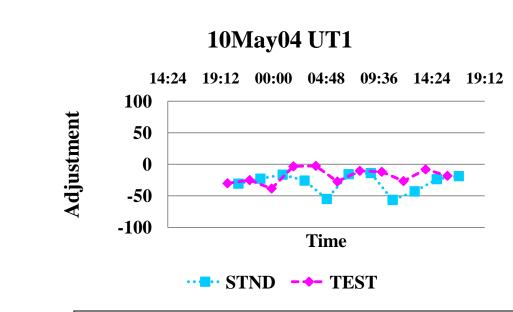
Sessions observations. We would like estimated RMS parameters to be insensitive to this loss. A session is robust if parameters do not change very much with the loss of a single source.

> To compare the robustness of the techniques, we show three USNO Intensives with varying levels of sky coverage ranging from good to bad, paired with TEST Intensives. For each session we ran a series of solutions in which we suppressed a single source and estimated UT1. We did this for all sources in the session and computed the scatter of the estimates. These results are summarized in table 2. The lower the scatter, the more robust the estimates.

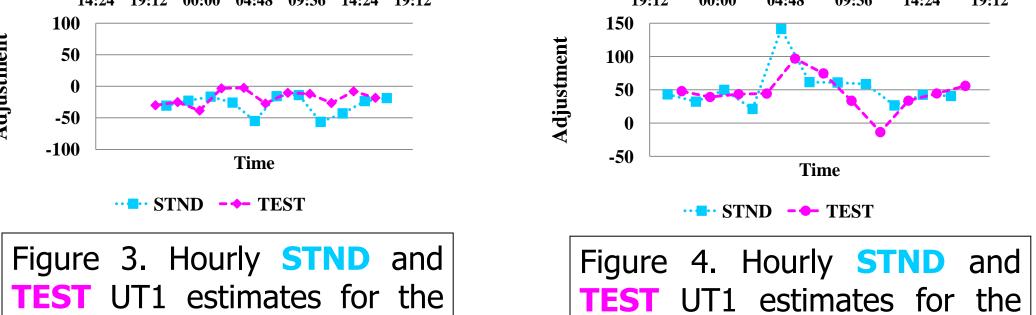
The TEST Intensives are much more robust than the USNO Intensives because their sky coverage is better and they use more sources. Hence the loss of a single source does not change the sky coverage as much as in the **USNO** Intensives.

6. UT1 Estimates in the R&D sessions

The three figures below compare UT1 estimates from the STND and TEST Intensives. Each point in figure 2 plots the RMS of the UT1 estimates from the STND vs. the TEST Intensives from one of the nine R&Ds. For each experiment, the TEST Intensives have less scatter and are therefore better. Figures 3 and 4 show the UT1 estimates for two R&Ds. We must still investigate discrepancies between the STND and TEST UT1 estimates within each R&D.



R&D with the least scatter.



R&D with the most scatter.

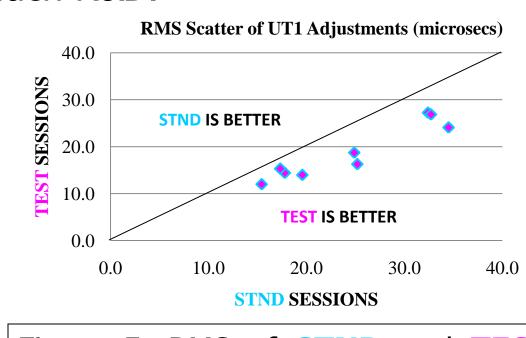
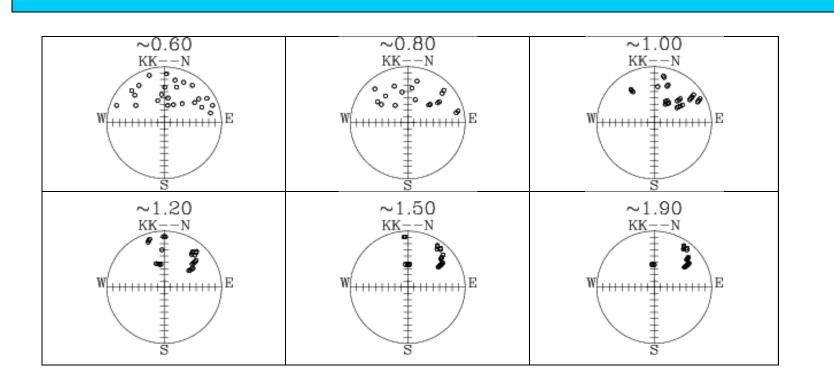
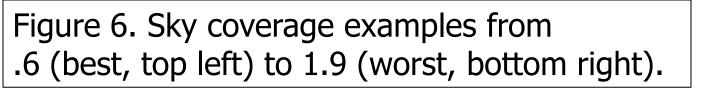
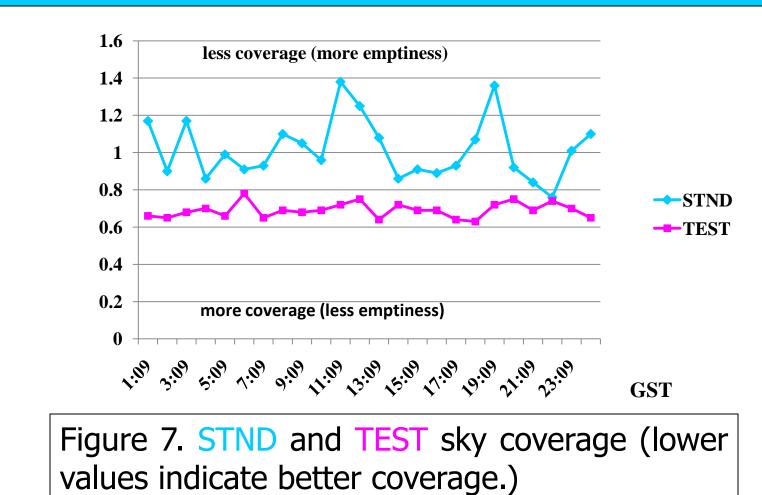


Figure 5. RMS of STND and TEST UT1 estimates for each R&D session The diagonal line indicates parity.

7. Sky coverage in the R&D sessions







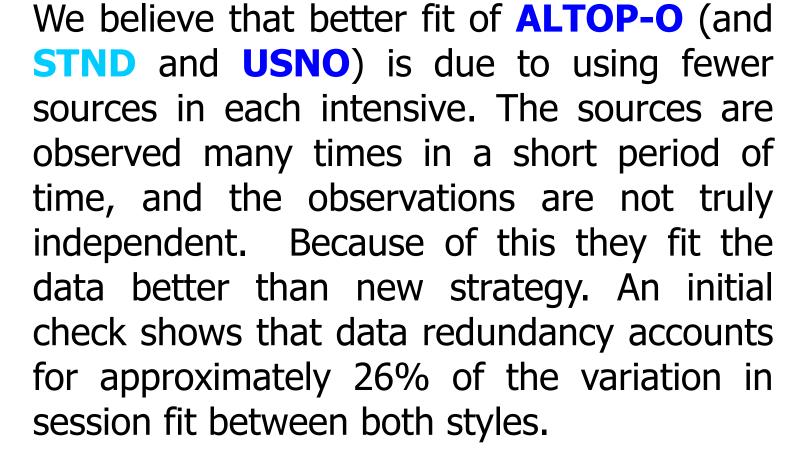
A major goal is to improve sky coverage in order to improve robustness. To assess sky coverage, we sample a grid of points and calculate their distance from the nearest observation, then sum the distances and scale them. Figure 6 shows some examples of source distributions and coverage numbers. A lower number indicates smaller holes in the sky sampling, or better coverage.

Figure 7 compares STND and TEST sky coverage. For each of 24 GSTs, we average the sky coverage values of all applicable STND and of all TEST sessions. The TEST values have better sky coverage at all GSTs except the one corresponding to mid November (22:09), which has strong, well-distributed sources even under the original scheduling strategy.

8. First assessment of operational use of the new scheduling strategy

Starting in July 2010, USNO began to use the new strategy for alternating IVS-INT01 sessions. By the end of February 2011, USNO had observed 34 new style (ALTOP-N) and 36 old style (ALTOP-O) sessions; the numbers are low due to a 3-month long repair of one antenna. We analyze all sessions (32 ALTOP-N and 35 ALTOP-O) with at least 12 observations (2 times the number of estimated parameters) here. Table 3 shows that the ALTOP-N sessions meet the goal of increased sky coverage, but does not reduce the UT1 formal error. This is caused, indirectly, by the fact that the session fit is higher for ALTOP-N.

	ALTOP-O		ALTOP-N	
Avg. # of obs achieved	16.6	✓	15.5	
Avg. # of sources	7.2		13.5	√
Avg. sky emptiness	1.2		0.8	✓
Avg. X-band SNR	30.2	✓	24.9	
Avg. session fit	37.0 ps	✓	55.2 ps	
Avg. UT1 formal error	14.5 μs	✓	17.1 μs	



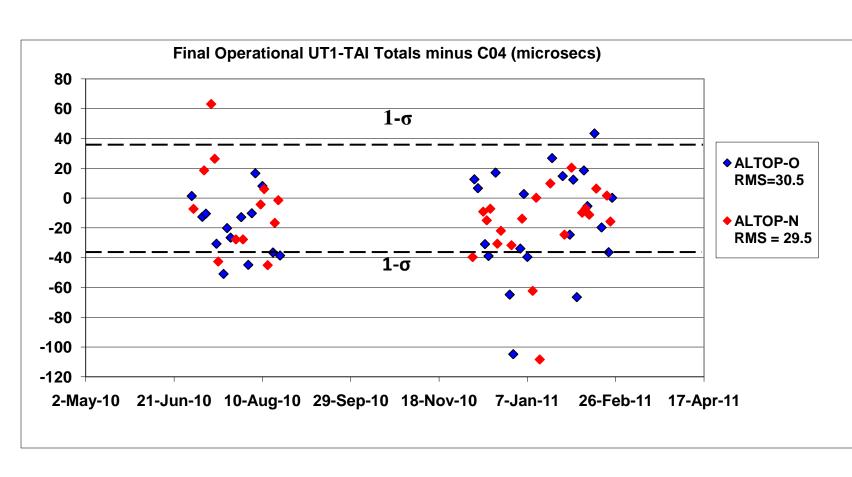


Figure 8. ALTOP-O and ALTOP-N minus C04 series

Figure 8 compares the **ALTOP** UT1-TAI totals to the C04 series totals. The **ALTOP** values are from a solution that used an apriori EOP file made 10 days after the final session. The RMS of the totals is 1µs lower for the new case, and most totals are reasonably close to C04. But operational UT1 formal errors are usually under 35 µs, so several sessions exceed the expected 1σ limit (the dashed lines), for both the ALTOP-O and ALTOP-N cases, and we must investigate this.

9. Conclusions and remaining work

The new scheduling technique meets the goal of improved sky coverage and should protect the UT1 estimates from source loss. Its UT1 estimates also show less scatter than those from the old technique, and its totals are generally close to the C04 totals. But we must investigate why some R&D STND and TEST UT1 estimates are discrepant, and we must investigate further why the new technique yields higher UT1 formal errors and higher than expected session fits.